UNIVERSITY OF CALIFORNIA PUBLICATIONS

COLLEGE OF AGRICULTURE
AGRICULTURAL EXPERIMENT STATION
BERKELEY, CALIFORNIA

PEAR POLLINATION

BY

WARREN P. TUFTS AND GUY L. PHILP

BULLETIN No. 373

DECEMBER, 1923

UNIVERSITY OF CALIFORNIA PRINTING OFFICE
BERKELEY, CALIFORNIA
1923

Digitized by the Internet Archive
in 2012 with funding from
University of California, Davis Libraries

http://www.archive.org/details/pearpollination373tuft

PEAR POLLINATION

By WARREN P. TUFTS and GUY L. PHILP

Whether the Bartlett and other leading varieties of pears require or are benefited by cross-pollination is a question which is arousing increasing interest on the part of pear growers, especially since the publication of a preliminary report on pear pollination.[1] This report being now out of print, it seems desirable to present at this time all the data available regarding the pollination requirements of the different pear varieties grown in California.

The fact that Bartlett trees, planted without any regard to cross-pollination, have yielded profitable crops under valley conditions, has led some to believe that this variety is self-fertile. On the other hand, these same growers have noticed when they have a stray tree of some other variety in their orchard that the surrounding Bartletts are more fruitful than the remainder of the orchard. This seems to indicate that the Bartlett, under valley conditions, is benefited by cross-pollination. In the Sierra Nevada foothills, thoughtful and observant growers have felt sure that the Bartlett, under their conditions, is always self-sterile. With the increased plantings of pear varieties other than Bartlett under both valley and foothill conditions, the pollination question assumes a still greater importance.

Waite[2] discovered about thirty years ago that the Kieffer pear, a leading variety of the eastern and middle states, is practically self-sterile. Since that time there has been much discussion throughout the country as to whether or not certain varieties other than the Kieffer could be benefited by cross-pollination and, if so, what varieties could be depended upon to serve as pollinators.

Fletcher[3] states that: "The results of hand-pollinating 8408 Kieffer pear blossoms and 9867 Bartlett pear blossoms in the years 1903, 1906, and 1907 indicate:

"1. In West Virginia and Michigan, and probably in other parts of the east, unsatisfactory results may be expected from planting either Bartlett or Kieffer in large blocks so that cross-pollination by insects is not general.

---

[1] Tufts, W. P., Pollination of the Bartlett Pear, Calif. Agr. Exp. Sta. Bull. No. 307, May, 1919.

[2] Waite, M. B., Pollination of Pear Flowers, Bull. 5, Div. Veg. Path., U.S. Dept. Agr., 1894.

[3] Fletcher, S. W., Report of Va. Agr. Exp. Sta., 1909–1910.

"2. Anjou, Lawrence, Duchess, and Kieffer are satisfactory varieties for planting with Bartlett, so far as pollination is concerned. Some years the Kieffer does not blossom simultaneously with Bartlett, but usually the blossoming seasons overlap sufficiently."

Kraus[4] advises planting Clairgeau, Anjou, Howell, or Kieffer with Bartlett for the purpose of affecting cross-pollination.

Wisker[5] says that: "California's pear profits would be greater if some other variety were planted with Bartlett for cross-pollination. Anjou, Bosc, and Comice are good pollinators and sell for higher prices than Bartlett. We have increased the fruitfulness of an old Bartlett orchard more than 200 per cent by inter-grafting other varieties."

Weldon[6] believes that: "The best results in growing Bartlett pears cannot be attained unless other varieties are planted with them in the orchard. Despite the evidence that this should be done, there are thousands of acres of Bartletts being planted in California each season with utter disregard of the benefits that might be derived by planting one or more varieties for cross-pollination. In certain new pear-growing sections, the writers have recently seen thousands of acres of Bartletts in blocks of five acres to more than one hundred acres each, with no other varieties near, except possibly an occasional tree of some favorite pear planted for home use.

"In some of these sections heavy winds and extremes of heat and cold occur, making more necessary the strictest attention to every detail that would tend to increase productivity. The fruit in general is good, and the trees everywhere have done well. So far as it has been possible to determine, they are self-fertile to a remarkable degree when the existing conditions are taken into consideration, but it is safe to predict that there will be years of short crops because of the absence of other pears, and the average production of these sections throughout a series of years will be far below what it would be with other varieties planted along with the Bartletts for cross-pollination purposes. There are older pear growing sections of the state where large areas of Bartletts have been planted by themselves and where the same arguments against the practice may be used."

Although practically all writers agree in advising the inter-planting of other varieties to pollinate the Bartlett, even in the valley locations in California, nevertheless the bulk of the acreage planted

[4] Kraus, E. J., The Pollination Question, Ore. Agr. Exp. Sta. Circ. Bull. No. 20, 1912.

[5] Wisker, A. L., Price List Loma Rica Nurseries, 1915–1916.

[6] Weldon, G. P., Pear Growing in California, Calif. State Com. of Hort., p. 234, 1918.

to Bartlett in the state contains no other variety. The authors of this paper outlined and performed certain experiments during the seasons of 1916, 1917, 1918, 1919, 1920, 1922, and 1923 designed to test the accuracy of the observations enumerated above.

PROBLEMS OF PEAR POLLINATION

Inasmuch as the Bartlett is the pear of greatest commercial value in California, more attention in these experiments has been given to this variety than to others. The increasing interest of pear growers in varieties other than the Bartlett has resulted in the collection of some data with regard to the pollination requirements of certain of these sorts.

In planning the work of which this bulletin is a report the writers have had in mind the differences of altitude, climate, and soil, existing in foothill, valley, and coastal regions in California, and have attempted to secure at least a partial solution of the following problems for these various conditions.

1. Will pears when planted in solid blocks be commercially profitable without pollinizers? If found to be profitable under these conditions, these varieties may be termed *self-fertile;* if unprofitable, they should be termed *self-sterile.*[7]

2. If pears will not, under all conditions, produce profitably in the absence of cross-pollination, what varieties should be used as pollinizers? This is a question of inter-fertility.

3. If it should be found that by inter-planting, the yield per tree can be increased, will the increase per acre make inter-planting commercially profitable?

4. Even though two varieties may pollinate each other, it is important that the following points should always be considered in selecting pollinizers:

a. Commercial value of the pollinizer.

b. Coincidence of bloom of the pollinizer with that of the variety to be pollinated.

c. Succession of ripening of the varieties, for convenience in harvesting.

d. Amount of pollen produced by the pollinizer.

e. Germinability of the pollen produced by the pollinizer.

[7] The writers prefer the terms "barren" and "fruitful" as explained by Kraus in the Journal of Heredity, vol. 6, no. 12, pp. 549–557, rather than the inexact terms, "sterile" and "fertile." The latter terms have been used in this paper on account of the fact that the general public is more or less familiar with these expressions.

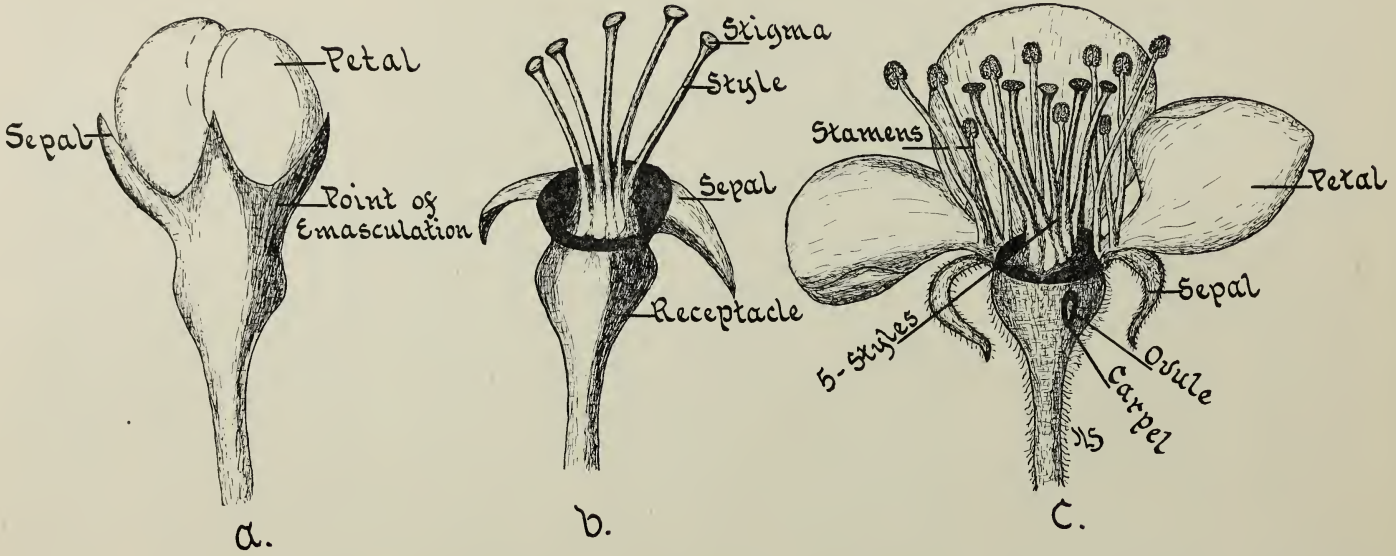

Fig. 1.—*a.* Unopened pear blossom at proper stage of development for emasculation (removal of male elements, the stamens). *b.* Pear blossom after emasculation. Petals, portions of the calyx, and stamens have been removed by a cut just below the point of attachment of the stamens. *c.* Median longitudinal section of an open pear blossom showing the parts of the complete flower.

ORGANIZATION OF THE WORK

The methods employed for investigating the problems just outlined were those commonly in use in cross-pollination experiments. Briefly stated, this consisted of removing the stamens, the pollen-bearing organs, from the flowers to be pollinated (fig. 1) and then applying the desired kinds of pollen by hand. Accurate counts of the hand pollinated flowers were made and recorded. The fruits resulting from these artificial pollinations were counted and the proper records made after the June drop and again at harvest.

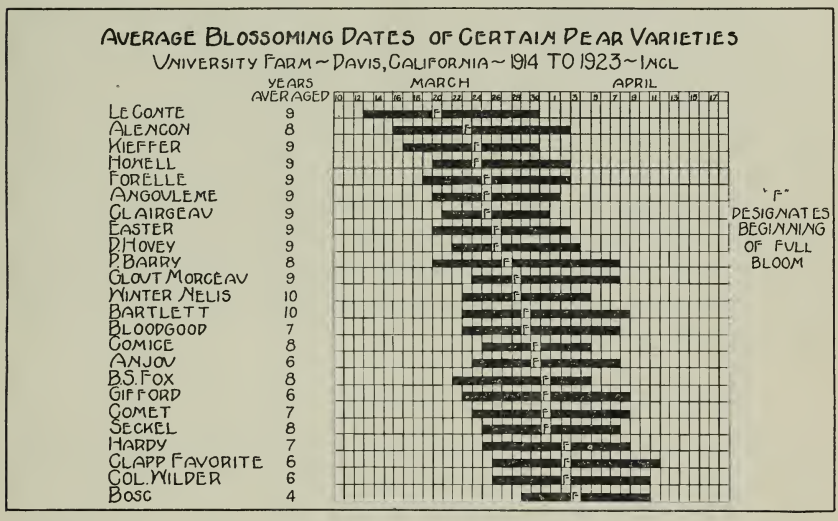

Fig. 2.—The average dates of first, last, and full bloom of certain pear varieties covering a period of four to ten years. The number of years averaged is shown in a separate column.

During the seasons of 1916, 1917, 1920, and 1923, experiments were conducted in the University Farm orchards at Davis, where typical Sacramento Valley conditions prevail. The trees are, at this writing, fourteen years old and are in an excellent state of vigor. In 1918 and 1919 experiments were conducted in the Vaca Valley Ranch orchards of the Earl Fruit Company at Vacaville. The trees are in full bearing, and are growing on some of the best soils in the valley. During the seasons of 1918, 1919, 1922, and 1923, certain experiments were conducted on the Loma Rica Ranch at Grass Valley. The trees in the Loma Rica orchards are nine years old and are making a moderate vegetative growth. This orchard is planted on typical red soil of the Sierra Nevada foothills at 3000 feet elevation. In 1920, experiments were conducted in the Santa Clara Valley, in the Keeble, Wilcox, and

McCurdy orchards. The trees in these latter orchards are in full bearing and in good condition. Several crosses were made in 1922 in the Searby orchard in the Occidental district of Sonoma County. Here the trees are healthy and in full bearing.

THE BLOOMING PERIOD OF CERTAIN PEAR VARIETIES

Figure 2 (p. 7) shows the average dates of the first, last, and full bloom of twenty-five pear varieties, as grown at the University Farm, Davis, for the years 1914 to 1923 inclusive (unless otherwise noted). Attention is called to the fact that the blooming period of the Bartlett is considerably longer than that of any other variety included in these studies. A careful study of these data as well as those presented by Weldon,[8] including the blooming dates of nearly sixty varieties, leads to the conclusion that, with the possible exception of a few very early blooming sorts such as the LeConte, Forelle, Kieffer, and Clairgeau, the blooming period of the Bartlett coincides very well with that of practically all other important varieties. Even the very early blooming varieties just mentioned do not, on the average, reach the height of their bloom many days before the Bartlett, and in most years their blooming periods overlap sufficiently to make them available as pollinators.

PRODUCTIVENESS AND VIABILITY OF POLLEN USED

In seven years' tests, there have been only three cases where pollen failed to give a satisfactory artificial germination. These were Bloodgood and Seckel in the year 1920 and Surprise in 1923. In the case of Seckel, the self-pollinated flowers produced a three per cent set, indicating a partial germination under natural conditions. No reason can be given for the failure of the other two varieties of pollen to germinate artificially.

Pear pollen, on the average, does not give as high germination tests as some of the other fruits, although a sufficient number of the pollen grains germinate to insure thorough pollination whenever the pollen is applied artificially.

In selecting a pollinizer for his commercial orchard, the grower must take into consideration not only whether the pollen produced by a certain variety is viable, but also whether the variety selected is a good pollen producer. Fortunately all varieties tested have proved to be abundant pollen producers. Table 1 gives the average artificial germination of the different varieties used.

[8] Weldon, G. P., Pear Growing in California, Calif. State Com. of Hort., p. 235, 1918.

TABLE 1

GERMINABILITY OF POLLEN

Percentage germination in a 12 per cent cane sugar solution

Seasons 1916 to 1923, inclusive

Variety	Source	1916	1917	1918	1919	1920	1922	1923
Alencon	Univ. Farm					12	10	
Anjou	Univ. Farm				8	22	40	
Anjou	Grass Valley			32			20	
Angouleme	Univ. Farm	63	22			41	73	
Bartlett	Univ. Farm	26	45	76	26	80	58	62
Bartlett	Grass Valley			42		75	80	31
Bartlett	Vaca Valley			19				
Bartlett	Sonoma Co						30	
Bartlett	Santa Clara (Mc)					62		
Bloodgood	Univ. Farm					0	18	
Bloodgood	Santa Clara (W)					62		
Bosc	Univ. Farm				16	22	5	
Bosc	Grass Valley						15	21
Clairgeau	Univ. Farm		26		22	82	82	69
Clairgeau	Grass Valley						85	
Clairgeau	Santa Clara (K)					54		
Clapp Favorite	Univ. Farm					46		88
Col. Wilder	Univ. Farm				24		15	35
Comice	Univ. Farm			74	21	36	44	73
Comice	Grass Valley			43			18	13
Comice	Santa Clara (K)					58		
Dana Hovey	Univ. Farm				35	40	18	88
Dana Hovey	Grass Valley			58			8	
Easter	Univ. Farm		63	39	29	44	37	52
Easter	Grass Valley						10	
Easter	Santa Clara (Mc)					45		
Flemish Beauty	Univ. Farm						31	
Forelle	Univ. Farm				15		31	90
Forelle	Grass Valley						20	
Gifford	Univ. Farm					21	45	
G. Morceau	Univ. Farm					17	18	
G. Morceau	Santa Clara (Mc)					30		
Hardy	Univ. Farm					17	19	
Hardy	Santa Clara (K)					33		
Howell	Univ. Farm		21	25	6	17	42	
Howell	Grass Valley						58	
Howell	Santa Clara (S)					55		
Kieffer	Univ. Farm				23		13	
Le Conte	Univ. Farm				25	38	15	
Lincoln	Grass Valley						19	
Madeline	Univ. Farm						63	
Patrick Barry	Univ. Farm				6	18	27	91
Patrick Barry	Grass Valley						38	
Seckel	Univ. Farm				29	0		87
Seckel	Grass Valley						70	
Surprise	Univ. Farm							0
W. Bartlett	Grass Valley						36	
W. Nelis	Univ. Farm	9	41	45		28	15	44
W. Nelis	Grass Valley			36		11	17	11
W. Nelis	Santa Clara (Mc)					36		
W. Seckel	Santa Clara (Mc)					21		
	Average	33	36	44	20.3	35	33.6	57

Mc, McCurdy orchard; K, Keeble orchard; W, Wilcox orchard; S, Smith orchard—all in the Santa Clara Valley.

RELATION OF NORMAL SET TO FINAL CROP

Immediately after the petals fall, each flower begins to form a fruit. During the following two or three weeks a certain percentage of these young fruits, for reasons not fully understood, drop off, leaving only a rather low percentage of the total number of original blossoms to continue development. It is quite necessary that this drop take place, as the tree under average circumstances would never be able to carry so many fruits through to maturity. Just what factors determine which of these young fruit shall drop is not at present known. Later in the season there takes place still another falling of the young fruits known as the "June drop."

The expression *normal set* is a more or less technical way of designating the percentage of fruit which the tree sets under normal conditions when left open to insect pollination. It is obvious that the normal set may be determined at any time up to the end of the season by counting the fruits on a tree and comparing the number with the original bloom. In these experiments, approximately 2000 blossoms of each variety, well distributed over the trees, were counted each year and proper records kept to determine the normal set after the first drop, after the second drop, and at harvest time.

The questions at once arise as to what percentage of normal set at harvest time constitutes a full crop, and what is meant by a "full crop." What constitutes a full crop of any fruit is perhaps largely a question of opinion, judgment, or guess. It varies with such factors as variety, soil, and moisture conditions. What would be considered a full crop under foothill conditions would not necessarily be the same in a valley location.

Table 2 casts some light upon the question as it shows the normal set of the Anjou, Hardy, Clairgeau, Flemish Beauty, and Forelle in 1922, as grown under conditions existing in the University Farm orchards. The average yield of these trees has been reduced to an acreage basis. The trees under observation were planted during the spring of 1912, being twenty-four feet apart by the square system, which gives approximately seventy-five trees to the acre. Since planting, these trees have received good commercial care. All figures are based on pears harvested.

An examination of the figures presented in table 2 shows that too much emphasis must not be placed on mere percentages. It will be noted that the normal set for Hardy was only 3.5 per cent with a yield of 12,550 pounds of fruit, while Flemish Beauty on the other hand, had a normal set of 18.2 per cent with practically the same

yield. Forelle, with a normal set of 25.2 per cent, produced 31,875 pounds of fruit. These variations in yields are explained by the heavier bloom of those varieties maturing a heavy crop with only a small percentage of the blossoms setting.

These figures are presented to show the necessity of taking the "normal set" counts every year on the different varieties in order to secure a correct basis for judging results of artificial pollination.

TABLE 2

Comparison of Normal Set with Yield in Pounds per Acre

University Farm, Davis, 1922

Variety	Per cent	Pounds per acre
Anjou	7.1	12,851
Clairgeau	5.5	21,600
Hardy	3.5	12,550
Flemish Beauty	18.2	12,075
Forelle	25.2	31,875

POLLINATION REQUIREMENTS OF THE BARTLETT PEAR

A. Interior Valley Conditions

During the seasons 1916, 1917, 1920, 1922, and 1923, experiments were conducted in the University Farm orchards at Davis for the purpose of determining whether the Bartlett would set fruit with its own pollen under Sacramento Valley conditions. At the same time numerous crosses were made on the Bartlett to find the best pollenizers for that variety (fig. 3). The results of this work are summarized in table 3.

In solidly planted Bartlett orchards, it has been observed that in years of heavy bloom a two or three per cent set from the self-pollinated flowers may give a satisfactory yield. However, in the long run, experience teaches that there is likely to be many years of light crops, if only the one variety is planted.

It will be noted from a study of table 3 that self-pollinated flowers gave a distinctly lower set than did those crossed with pollen of other varieties except in the case of Howell in 1917 and Anjou in 1922. During all years the Bartlett showed evidence of self-sterility. Of the varieties used as pollinizers for the Bartlett, Winter Nelis has always given the highest set of fruit. The writers feel that under average conditions and over a long period of time this variety should be given

TABLE 3

Bartlett Pear Pollination in Interior Valley

Bartlett	1916		1917		1918		1919		1920		1922		1923	
	Number of blossoms used	Per cent set	Number of blossoms used	Per cent set	Number of blossoms used	Per cent set	Number of blossoms used	Per cent set	Number of blossoms used	Per cent set	Number of blossoms used	Per cent set	Number of blossoms used	Per cent set
Normal Set	1116	3.6	1947	8.2	1276	.....	3956	8.4	908	.1	2882	8.1	.....	3.0*
xSelf	205	2.4	423	1.9	424	9.7	364	7.1	382	0.0	1213	3.1	358	0.8
xSelf U. F.†							481	6.4						
xSelf G. V.‡									459	0.4				
xAngouleme	73	10.9	380	6.9										
xAnjou							359	14.0	445	7.4	422	2.1		
xBosc							280	16.0			282	12.2		
xComice					278	26.3	427	21.8			540	6.6	207	9.1
xClairgeau			201	3.0										
xEaster			109	2.9	308	23.1			303	17.1			312	11.8
xForelle							428	16.0						
xHardy							201	19.4			711	5.7		
xHowell			105	1.0	238	19.8	328	13.4			382	4.4		
xWinter Nelis	308	7.5	162	10.5	256	23.4	314	13.0	334	26.6	547	13.7	381	13.0

Note:—This work was all accomplished in the University Farm Orchards at Davis, except in the years 1918 and 1919 when the Vaca Valley Orchards at Vacaville alone were utilized.

*Per cent. estimated.

† Bartletts at Vacaville selfed with pollen from Bartletts at University Farm.

‡ Bartletts at University Farm selfed with pollen from Bartletts at Grass Valley.

preference as a pollinizer for the Bartlett. Comice, Bosc, Easter, and Hardy also have given satisfactory results and are recommended in the order named. Howell, Angouleme, Anjou, and Forelle have likewise been fairly satisfactory as pollinizers.

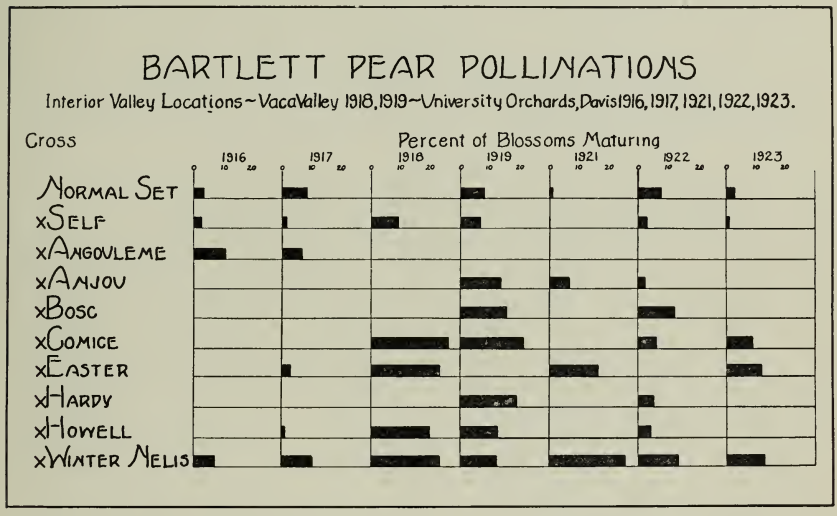

Fig. 3.—This chart shows the influence of various kinds of pollen when applied to the flowers of the Bartlett pear under interior valley conditions. Note the comparatively light set of fruit when the Bartlett flowers were self-pollinated.

B. Coastal Conditions

The work under coastal conditions was done in 1920 in the Santa Clara Valley and in 1922 in Sonoma County. The results of this work are presented in table 4.

A study of table 4 shows some rather interesting results. In Santa Clara Valley, the Wilcox and McCurdy orchards exhibited a wide difference both in the normal set and self-pollination tests. In the former orchard, the Bartlett was practically self-sterile, while in the latter it was self-fertile. Also, the normal set in the Wilcox orchard was less than half that in the McCurdy orchard. Both of the orchards are considered good producers. Possibly the differences in soil conditions and cultural treatments may be responsible for the seemingly conflicting results given above.

Comice and Winter Nelis proved to be the best pollinizers for the Bartlett, while Clairgeau and Easter gave only fair results; Glout Morceau and Howell proved to be practically inter-sterile with the

Bartlett. Since facilities have not been available for repeating these experiments, definite conclusions cannot be drawn at this time.

In Sonoma County, the only work attempted was self-pollinating the Bartlett and crossing that variety with the Winter Nelis. Weather conditions were not favorable for the setting of fruit in this section in 1922, but while the percentage set was small the crop was fairly satisfactory. It should be noted that while the Bartlett was to a certain degree self-fertile, the set was materially increased by using Winter Nelis as a pollinizer.

TABLE 4

BARTLETT PEAR POLLINATION UNDER COASTAL CONDITIONS

Bartlett	1920		1922	
	Number of blossoms counted	Per cent set	Number of blossoms counted	Per cent set
Normal Set	1980 Mc	20.0	2013 S	1.2
Normal Set	3718 W	9.8		
xSelf	506 Mc	12.4	472 S	2.5
xSelf	549 W	0.5		
xClairgeau	493 W	4.8		
xComice	524 W	24.2		
xEaster	500 W	4.4		
xGlout Morceau	504 W	0.4		
xHowell	484 W	0.6		
xWinter Nelis	548 W	23.5	451 S	5.3

NOTE:—1920. Work done in Santa Clara County. Mc, McCurdy orchard; W. Wilcox orchard.
1922. Work done in the Searby orchard, Sonoma County.

C. SIERRA NEVADA FOOTHILL CONDITIONS

Pollination experiments were conducted in the Sierra Nevada foothills during the seasons 1918, 1919, 1922, and 1923. The results of this work are presented in table 5.

It is the general opinion of pear growers that under Sierra Nevada foothill conditions, Bartlett pears must be cross-pollinated to produce satisfactory crops. A study of table 5 indicates this to be the case. During three of the four years that these experiments were in progress, the Bartlett was largely self-sterile, this self-sterility occurring entirely too often to justify an orchardist in attempting to grow pears without providing for cross-pollination (fig. 4).

The Winter Nelis has proved to be the best pollinizer for the Bartlett. Although all the other varieties tested proved to be satis-

factory pollinizers, preference should possibly be given to Winter Nelis, Bosc, Comice, and Anjou in the order named.

Table 6 presents the results of an experiment designed to show, from the average yield of two comparable orchards, the benefits to be derived from cross-pollination. The orchard of P. M. Beaser of

TABLE 5

BARTLETT PEAR POLLINATION IN SIERRA NEVADA FOOTHILLS

	1918		1919		1922		1923	
	Number blossoms counted	Per cent set	Number blossoms counted	Per cent set	Number blossoms counted	Per cent set	Number blossoms counted	Per cent set
Bartlett								
Normal Set..	2916	19.5	2583	3.8	1732	2.7	3026	7.2
xSelf.....	918	1.3*	398	16.0	634	0.1	926	0.0
xAnjou.....	518	18.7	377	18.8	517	1.9		
xBosc.....	426	20.6	396	27.2	500	1.8	612	11.0
xComice.....					532	4.8	546	13.0
xEaster.....			310	19.3	429	2.3		
xHovey.....	459	15.4	407	21.8	496	3.0		
xHowell.....					530	3.9		
xW. Nelis	414	20.1			452	5.1	893	14.0

*Fruit small.

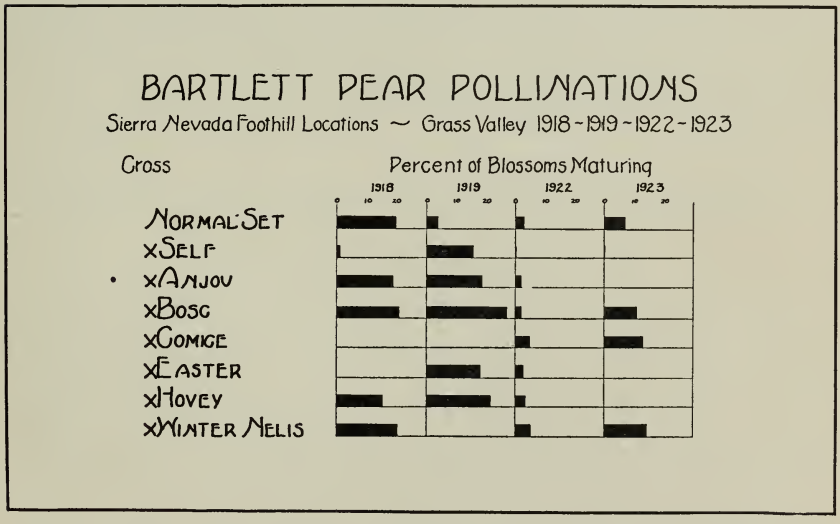

Fig. 4.—This chart shows the influence of various kinds of pollen when applied to the flowers of the Bartlett pear under Sierra Nevada Foothill locations. Note the failure of the trees to set fruit when self-pollinated.

Chicago Park, Nevada County, consists of a solid block of one thousand Bartlett pear trees, no provision having been made for cross-pollination. These trees are perhaps twenty-five years old. There is located on the Loma Rica Ranch, some eight miles away, a small block of old Bartlett trees of about the same age and vigor as those on the Beaser place. Many of these trees had, however, during the six or eight years previous to 1918, been topworked to other varieties. With the exception of the presence of pollinating varieties close at hand on the Loma Rica Ranch, the two orchards just described were in all respects comparable. Both orchards bloomed profusely in 1918.

TABLE 6

COMPARISON OF YIELD ON BARTLETT TREES IN NEVADA COUNTY WITH AND WITHOUT POLLINATING VARIETIES, 1918.

With Pollinating Varieties			Without Pollinating Varieties		
Number blossoms counted	Per cent set	Average yield per tree in packed boxes	Number blossoms counted	Per cent set	Average yield per tree in packed boxes
3007	14.9	2.19	3170	6.0	.77

The figures show that the trees provided with cross-pollination produced a crop almost three times as great as that produced by the trees which did not receive cross-pollination. It should also be noted that the favorable showing for the trees receiving cross-pollination was made in spite of the fact that this orchard lost much of its fruit as a result of the ravages of pear blight.

POLLINATION REQUIREMENTS OF CERTAIN PEAR VARIETIES OTHER THAN THE BARTLETT

A. Interior Valley Conditions

Some twenty-five pear varieties have been tested as to their pollination requirements when grown under interior valley conditions. These experiments were conducted in the University Farm orchards at Davis. The major portion of this work consisted of the determination of normal sets and the testing of the varieties for self-sterility or self-fertility. A few cross-pollinations were made between some of the varieties. Tests have been conducted for from one to four years. The results of this work are presented in table 7.

TABLE 7

POLLINATION OF PEAR VARIETIES OTHER THAN BARTLETT

University Farm, Davis, 1919, 1920, 1922, 1923

Variety	1919		1920		1922		1923	
	Number counted	Per cent set	Number counted	Per cent set	Number counted	Per cent set	Number counted	Per cent set
Alencon								
Normal Set			990	0.0	314	1.2		
xSelf			511	0.0	559	0.0		
Angouleme								
Normal Set			881	0.1	240	10.0		
xSelf			293	0.0	483	6.4		
Anjou								
Normal Set	249	17.3	724	7.0	183	7.1		
xSelf	79	6.1	335	0.6	710	20.4		
Bloodgood								
Normal Set			843	7.7	306	13.4		
xSelf			576	0.3	427	0.0		
Bosc								
Normal Set	254	26.1					900	48.6
xSelf	227	0.0						
xComice							272	63.2
xEaster							179	29.6
B. S. Fox								
Normal Set			246	12.0				
xSelf			265	0.1				
Clairgeau								
Normal Set	172	23.8	839	5.9	757	5.5	1313	15.7
xSelf	193	2.1	307	0.0	432	0.0	374	7.3
xComice							232	14.5
xW. Nelis							358	10.6
Clapp Favorite								
Normal Set			530	14.0			1326	8.7
xSelf			288	0.6			342	2.6
Col. Wilder								
Normal Set	512	15.4	736	7.4			1643	20.3
xSelf	451	13.1	300	0.0	214	0.0	548	6.0
Comet								
Normal Set			498	0.9				
xSelf			302	0.0				
Comice								
Normal Set	499	15.2	727	7.0	340	2.3	1549	19.9
xSelf	433	5.3	811	6.0	161	1.2	260	6.5
D. Hovey								
Normal Set			122	2.4	884	3.9	1759	19.5
xSelf			168	0.0	581	0.3	392	11.7

TABLE 7—(*Continued*)

Variety	1919		1920		1922		1923	
	Number counted	Per cent set	Number counted	Per cent set	Number counted	Per cent set	Number counted	Per cent set
Easter								
Normal Set			799	4.0	376	4.0	1601	3.7
xSelf			275	0.7	356	0.8	317	6.3
Flemish Beauty								
Normal Set					142	18.2		
xSelf					226	6.2		
Forelle								
Normal Set	403	8.7	608	10.0	258	25.2		
Self			315	0.0	472	0.0		
Gifford								
Normal Set			501	14.0	710	10.3		
xSelf			274	0.0	117	2.7		
Glout Morceau								
Normal Set			538	3.9	239	3.4		
xSelf			307	0.6	276	2.1		
Hardy								
Normal Set	317	13.6	701	8.5	752	3.5	1555	3.8
xSelf	442	9.3	227	7.5	530	0.3		
xComice							441	4.7
xEaster							381	14.7
Howell								
Normal Set	957	6.8	673	0.6	64	2.0		
xSelf	463	3.5	277	0.3	407	4.4		
Kieffer								
Normal Set	385	4.9	640	8.2	441	14.9	1414	7.1
xSelf	165	5.5	278	0.0	551	0.2	267	0.0
LeConte								
Normal Set	900	7.5	457	14.0	1528	3.6		
xSelf	209	0.0	557	0.0	329	0.0		
P. Barry								
Normal Set			938	7.9	301	8.3	1628	11.5
xSelf			311	0.9	474	0.8	319	2.8
Madeline								
Normal Set					1003	8.1		
xSelf					151	0.0		
Seckel								
Normal Set	57	63.2	516	22.0		15.0*	533	77.5
xSelf	195	4.6	307	3.0	579	0.0	423	19.8
Winter Nelis								
Normal Set	1048	12.4	804	6.0			108	6.7
xSelf	442	0.0	238	0.0			1464	0.2
xSelf G.V.†			341	0.0				
Comice							764	16.5

* Per cent set estimated. † Pollen from Grass Valley.

In order to summarize the results presented in table 7, the writers have segregated the varieties into three groups as follows:

Self-Sterile		Self-Fertile		Doubtful		
Variety	Years tested	Variety	Years tested	Variety	Number years self-fertile	Number years self-sterile
Alencon	2					
Bloodgood	2	Comice	4	Angouleme	1	1
B. S. Fox	1	Flemish Beauty	1	Anjou	2	1
Comet	1	Hardy	3	Bosc	1	1
Forelle	2	Howell	3	Clapp Favorite	1	1
Le Conte	3			Clairgeau	2	2
Madeline	1			Col. Wilder	2	2
Winter Nelis	3			Dana Hovey	1	2
				Easter	1	2
				Gifford	1	1
				G. Morceau	1	1
				Kieffer	1	4
				P. Barry	3	2
				Seckel	1	1

Those varieties listed as self-sterile must be provided with some other variety to pollinate them.

While the self-fertile varieties may be expected to produce good crops without pollinizers, it should be noted from the table that in no case did the self-pollinations equal the normal set. The advantage of cross-pollination is thus clearly shown since these trees are located in a variety orchard, where abundant opportunity for cross-pollination is afforded.

The doubtful varieties are those which have not behaved consistently from year to year. For instance, the Anjou was self-fertile in 1919 and 1922, but largely self-sterile in 1920, and the Clairgeau was self-fertile two years and practically self-sterile two years. It would be inadvisable to plant these doubtful varieties in solid blocks, as there would be too many years when they would be self-sterile or practically so, and would not produce paying crops. Only a few cross-pollinations have been made with these varieties but in each case a very satisfactory set has been obtained.

B. Coastal Conditions

Experiments under coastal conditions have been rather limited, consisting of one year's trial in the Santa Clara Valley and work with one variety in Sonoma County. The results of this work are presented in table 8.

TABLE 8

Pollination of Pear Varieties Other than Bartlett
Coastal Conditions

Variety	1920			1922		
	Number of blossoms counted	Number set	Per cent set	Number of blossoms counted	Number set	Per cent set
Bosc						
Normal Set	1987	527	26			
xSelf	410	82	20			
Clairgeau						
Normal Set	1901	92	4.8			
xSelf	422	0	0.0			
xForelle	205	3	1.4			
Comice						
Normal Set	1758	71	4.0			
xSelf	425	4	0.9			
xHowell	327	2	0.6			
xW. Nelis	304	91	29.9			
Easter						
Normal Set	2000	99	4.4			
xSelf	486	55	11.3			
Glout Morceau						
Normal Set	2000	123	6.1			
xSelf	892	75	8.4			
xEaster	353	54	15.0			
xW. Nelis	40	6	12.0			
Hardy						
Normal Set	2108	73	3.4			
xSelf	404	5	1.2			
xComice	299	81	27.0			
xW. Nelis	308	110	35.7			
Howell						
Normal Set	1237	15	1.2			
xSelf	531	0	0.0			
Winter Seckel						
Normal Set	1025	32	3.1			
xSelf	532	8	1.5			
Winter Nelis						
Normal Set	2000	218	10.0	1793	81	4.5
xSelf	486	7	1.4	485	1	0.2
xBartlett	342	59	17.0	220	31	14.0
xEaster	315	52	16.0			
xGlout Morceau	231	19	8.0			

From the preceding table it will be noted that Clairgeau, Comice, Howell, Hardy, and Winter Nelis proved to be self-sterile or practically so. Bosc, Easter, and Glout Morceau are self-fertile.

Although Winter Seckel produced considerable fruits when self-pollinated, it has been classified as partially self-sterile. Since the set from self-pollinations was low when compared with the normal set, the writers believe that this variety should not be planted in solid blocks.

C. Sierra Nevada Foothill Conditions

Experiments were conducted under foothill conditions during the years 1919, 1922, and 1923. The results of this work are presented in table 9.

A study of table 9 shows Anjou, Comice, D. Hovey, and P. Barry to be self-sterile or practically so. Bosc may be classed as doubtful since it was sterile one year and partially self-sterile the other. The one season's results indicate that Easter is self-fertile.

It is interesting to note that in all cases the Bartlett has proved to be a satisfactory pollenizer. With the exception of Winter Nelis × Bosc and the reciprocal cross, pollinations with Bartlett have given the highest yields. With the exception of Dana Hovey × Bartlett, all crosses made have increased the set over that obtained by the normal count, and in most cases the resultant set was two or three times as much as that produced under field conditions.

Reimer[9] observes in southern Oregon that the Bartlett is not a good pollinizer for Anjou and also that a satisfactory pollinizer for the Comice is yet to be found. The writers feel that the conflict between Oregon observations and the results obtained in California are perhaps due to climatic factors.

From the preceding discussion it seems reasonable to draw the following conclusions: Under Sierra Nevada foothill conditions all pear varieties should be considered as self-sterile—meaning that it is inadvisable to plant pears without provisions for cross-pollination. The Bartlett can be considered as a satisfactory pollinizer for other varieties.

INFLUENCE OF CROSS POLLINATION UPON THE JUNE DROP

Table 10 gives in detail the results of certain experiments conducted in the orchards of the Vaca Valley Ranch of the Earl Fruit Company at Vacaville during the season of 1918 (figs. 5 to 10, inclusive). This orchard consists of a solid block of Bartletts, no provision having been made for cross-pollination.

[9] Reimer, F. C., Better Fruit, vol. XVIII, Nov. 6, 1923.

TABLE 9

Pollination of Pear Varieties Other than Bartlett

Sierra Nevada Foothill Conditions

Variety	1919			1922			1923		
	Number of blossoms counted	Number set	Per cent set	Number of blossoms counted	Number set	Per cent set	Number of blossoms counted	Number set	Per cent set
Anjou									
Normal Set....	1747	51	2.8	2170	89	4.1			
xSelf.....	311	0	0.0	476	0	0.0			
xBartlett.....	218	32	14.6	386	27	7.0			
xBosc.....				364	21	5.7			
xHowell.....	300	28	9.3						
Bosc									
Normal Set....				2062	94	4.5	1398	56	4.0
xSelf.....				521	11	2.1	527	0	0.0
xBartlett.....				474	22	4.6	392	35	8.5
xW. Nelis.....				341	27	7.9	290	27	9.3
Comice									
Normal Set....				2188	0	0.0	2958	110	3.7
xSelf.....				770	0	0.0	1110	6	0.5
xAnjou.....				495	10	2.0			
xBartlett.....				477	20	4.2	552	51	9.2
xBosc.....				551	10	1.8	479	42	8.9
xW. Nelis.....				566	0	0.0	629	75	11.9
D. Hovey									
Normal Set....	1258	156	12.4						
xSelf.....	148	0	0.0						
xBartlett.....	120	3	2.5						
Easter									
Normal Set....	1048	55	5.2						
xSelf.....	274	9	3.0						
xBartlett.....	226	15	6.6						
P. Barry.....									
Normal Set....	1713	11	0.6						
xSelf.....	376	5	1.3						
xBartlett.....	330	37	11.2						
Winter Nelis									
Normal Set....	1559	53	3.3	2391	29	1.2	2537	259	10.0
xSelf.....	387	2	0.5				551	1	0.0
xAnjou.....				370	22	5.9			
xBartlett.....	352	11	3.1	477	48	10.0	534	85	15.9
xBosc.....				442	42	9.2	534	146	27.3
xComice.....				340	23	6.7	465	54	11.6
xEaster.....				408	38	9.3			

Fig. 5.—A typical example of the normal set in the Vaca Valley Ranch orchards, 1918. Two pears matured from seventeen blossoms—a 11.7 per cent set. In years of normal bloom a 10 per cent set would assure a satisfactory crop.

Fig. 6.—Two Bartlett pears set from eight blossoms pollinated with Bartlett pollen. A typical cluster of this variety when self-pollinated. Vaca Valley Ranch, 1918.

Fig. 7.—Five Bartlett pears set from twelve blossoms pollinated with Comice pollen. A typical cluster resulting from crossing Bartlett with Comice. Vaca Valley Ranch, 1918.

Fig. 8.—Four Bartlett pears set from seventeen blossoms pollinated with Easter pollen. A typical cluster resulting from crossing Bartlett with Easter. Vaca Valley Ranch, 1918.

Fig. 9.—Eleven Bartlett pears set from twenty-five blossoms pollinated with Howell pollen. A typical cluster resulting from crossing Bartlett with Howell. Vaca Valley Ranch, 1918.

Fig. 10.—Ten Bartlett pears set from twenty blossoms pollinated with Winter Nelis pollen. A typical cluster resulting from crossing Bartlett with Winter Nelis. Vaca Valley Ranch, 1918.

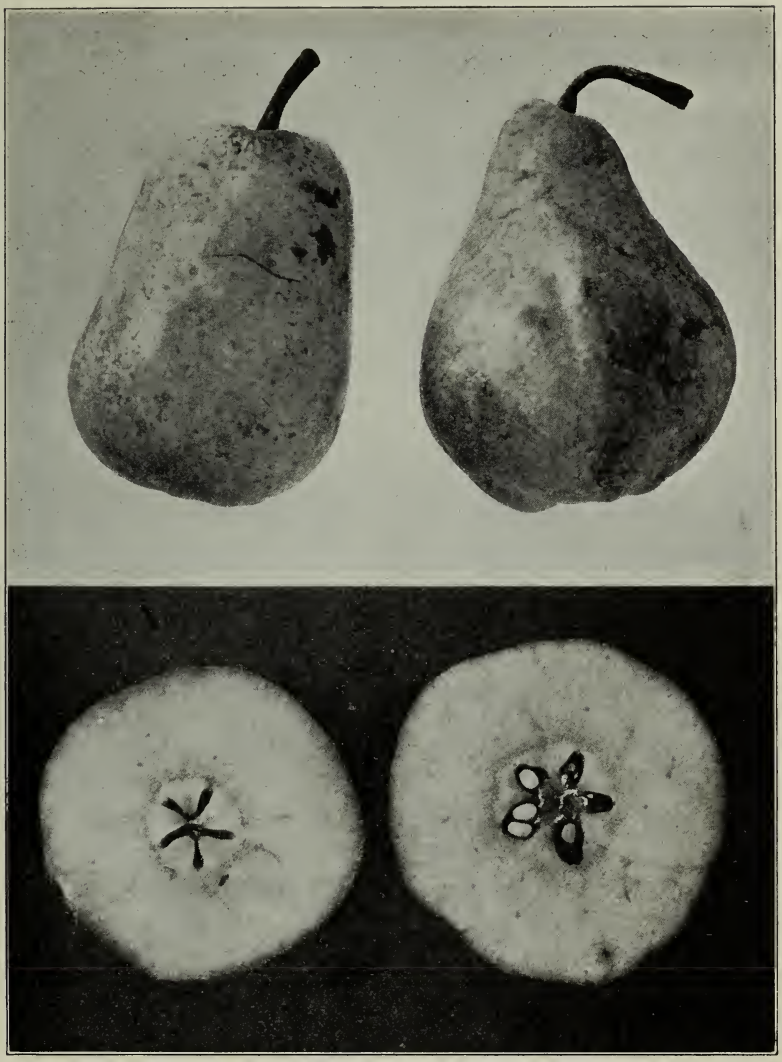

Fig. 11.—Bartlett pears (left), self-pollinated (right), cross-pollinated with Winter Nelis. Showing the characteristic shape of each and the relative amount of core tissue.

It is unfortunate that the normal set count of the fruits matured could not be secured. The branches on which these records were made received the customary hand thinning early in the summer and therefore later counts would not have been reliable.

TABLE 10

POLLINATION OF THE BARTLETT, 1918

Vaca Valley Ranch, Vacaville

Variety	Number of blossoms counted	Number set	Per cent apparently set May 10	Number fruits matured	Per cent matured
Bartlett					
Normal Set	1276	108	8.4	.....	.....
xSelf	424	79	18.6	41	9.7
xComice	278	90	32.3	73	26.3
xEaster	308	86	27.9	71	23.1
xHowell	238	63	26.4	47	19.8
xWinter Nelis	256	75	29.2	60	23.4

Those flowers which were self-pollinated matured a much smaller crop than did those which were crossed with pollen from other varieties. It is interesting to note from the above table that the loss from the June drop of those fruits resulting from cross-pollination amounted to only 20 per cent, while with those self-pollinated the loss was 48 per cent. This would seem to indicate that fewer pears will be lost at the June drop if adequate provision is made for cross-pollination.

Inasmuch as the resulting set in this orchard when the blossoms actually received their own pollen was more than double the normal set, it seems clear that the provision of some agency, preferably honey bees, for the transfer of pollen from flower to flower would be highly profitable.

INFLUENCE OF CROSS POLLINATION UPON MATURITY, SHAPE, QUALITY, PRODUCTION AND KEEPING PERIOD

Blanchard[10] observes that: "In the Antelope Valley Bartlett pears resulting from cross-pollinated flowers mature their fruit from two to three weeks earlier than those fruits resulting from self-pollination. There is also a marked increase in the yields from orchards having pollinating varieties present."

[10] Blanchard, V. F., Unpublished data, Los Angeles County, 1923.

Overholser and Latimer[11] report that: "The flavor of cross-pollinated pears from the Antelope Valley was richer, but had only about three-fourths as much edible flesh as the self-pollinated fruit, because of the amount of tissue comprising the core of the former. The characteristic shape of the self-pollinated Bartlett pear is different from the cross-pollinated pear (fig. 11). There was little apparent difference in the length of the keeping period between the self-pollinated and cross-pollinated Bartlett and Winter Nelis."

The writers do not know of any other section where the self-pollinated Bartlett behaves as it does in the Antelope Valley, but certainly under those conditions it is highly desirable to provide for cross-pollination.

Another variety where cross-pollination is highly desirable is in the case of the Glout Morceau, which generally produces irregular shaped fruits when self-pollinated.

RECOMMENDATIONS

From a study of the experimental data presented and from the observations and experiments of many orchardists of the state, the conclusion is inevitable that pear orchards should in general be provided with facilities for cross-pollination.

Since the Bartlett is the most important variety grown in the state at the present time, the question at once arises as to what variety shall be selected as a pollinizer for it. For foothill locations where the bulk of the crop is offered for "green" shipment, this question is probably not difficult to answer. In these places, the Anjou, Bosc, Comice, Howell, and Winter Nelis are all excellent pears, bringing prices equal to or better than the Bartlett for eastern shipment. These varieties may not give an equal tonnage with the Bartlett, but they are all fair producers. The Comice should be avoided in windy locations, since its skin is quite delicate and mars most easily.

In valley locations the question of providing cross-pollination for the Bartlett is more difficult. The grower must concede that where the set can be increased 100 per cent or more by the planting of one pollinating tree to every eight Bartletts, the returns per acre will still be greatly increased even though the fruit of the pollinating variety may have little or no commercial value. Although there has been no thorough attempt to test the adaptability of various varieties to different locations, the writers believe from the information in hand

[11] Overholser, E. L., and Latimer, L. P., Calif. Agr. Exp. Sta. Ann. Rept., p. 130, 1922.

that the Winter Nelis will prove, from all standpoints, to be the most efficient pollinizer for the Bartlett when grown under valley conditions. Comice, Bosc, Easter, and Hardy also have given satisfactory results and are recommended in the order named.

Where dried fruit is a primary product and where the fruit of the pollinizer for the Bartlett must also be dried, special difficulties are presented. No experiments have as yet been conducted in this state to determine the drying qualities of the various varieties. In order to avoid the use of artificial evaporators. the pollinizer must ripen its fruit at about the same time or shortly after the Bartlett. Practically all dried pears in California are sundried. Keeping especially in mind the time of ripening, the Howell and Hardy varieties seem to be the best pollinizers for the Bartlett where the entire crop is to be dried.

Under coastal conditions Winter Nelis and Comice should prove to be the most efficient pollenizers for the Bartlett.

Although comparatively few cross-pollinations have been made on varieties other than the Bartlett, the writers feel from the data presented that the Bartlett may be successfully used as a general pollinizer. This is especially true of the more important sorts, such as Anjou, Bosc, Comice, Hardy, Howell, Easter, and Winter Nelis.

POLLINATING AGENCIES

After planting inter-fertile varieties, the orchardist should by all means provide an agency for the transfer of the pollen from the trees of one variety to those of another. The common honey bee is by far the best carrier of pollen; it will pay the grower to keep bees even though he may not care to go into the honey business. Bees, however, are a very profitable side line for the orchardist, especially if alfalfa fields are available to work on after the blooming season of fruit has passed. About one hive of bees to an acre of bearing orchard should be provided. Preferably the hives should be scattered as widely as possible throughout the orchard during the blooming season. Experiments and experience have shown that little reliance can be placed on wind and insects, other than the honey bee, in effecting the transfer of pollen from tree to tree or, in fact, from flower to flower.

Gossard and Walton[12] show that under Ohio conditions, pear blossoms which have been pollinated for 72 hours are not likely to

[12] Gossard, H. A., and Walton, R. C., Dissemination of Fire Blight, Ohio Agr. Exp. Sta. Bull. 357, 1922.

be inoculated with pear blight and that susceptibility to the disease does not exist in blossoms that have been pollinated for 144 hours.

These writers infer that the presence of numerous honey bees in an orchard at blossoming time will insure a good crop of fruit by bringing about the pollination of each flower as soon as it unfolds, thus rendering a majority of the bloom non-susceptible to blight before the disease is generally diffused over the orchard.

The relation of bees to the spread of pear blight under California conditions is a question which requires additional investigation. The work in Ohio would seem to indicate that numerous bees in the orchard early in the season would be an advantage in restricting the "blossom blight," in addition to their necessity as pollinating agents.

Eliminating from consideration all conditions which may influence the fruitfulness of an orchard except those occurring at the blossom period, it may be said that the set is largely influenced by weather conditions at that time. Cold weather, aside from killing the blossoms or lowering the vitality of the pollen, often prevents bees from working. The same is true if cloudy, wet, and windy weather prevails. For their best work bees demand clear, warm, and quiet days, and since the weather at the time of bloom is often quite unsettled, it is readily seen that the blossoming period of the various pollinating varieties should overlap perhaps a week in order that there may be one or two days at least when the weather will be favorable for insect pollination.

ARRANGEMENT OF THE ORCHARD FROM A POLLINATION STANDPOINT

In planting an orchard it is desirable to have at least every sixth and preferably every fourth row of a pollinating variety. For convenience in the management of the orchard, it is best to plant two rows of one kind, then two rows of the pollinating variety, and so on; or, if it is desired to have more of one variety than another, four rows of the favorite variety, then two rows of the pollinizer, and repeat. For one reason or another, it is often desirable to reduce the number of pollinating trees to the minimum. Under these circumstances, one tree in twenty-five is perhaps sufficient, although at least one tree in eight is strongly recommended. It is seldom wise to graft over a part of a tree to the pollinating variety as this tends toward confusion and added expense in harvesting.

In planting one tree of the pollinizer to seven or eight of the main variety, the former should be placed as every third tree in every third row in such a way that the spaces in the pollinating rows are broken as indicated in the diagram, the "0" in each case representing a pollinating tree.

```
.  0  .  .  0  .  .  0  .  .  0  .  .
.  .  .  .  .  .  .  .  .  .  .  .  .
.  .  .  .  .  .  .  .  .  .  .  .  .
.  0  .  .  0  .  .  0  .  .  0  .  .
.  .  .  .  .  .  .  .  .  .  .  .  .
.  .  .  .  .  .  .  .  .  .  .  .  .
.  0  .  .  0  .  .  0  .  .  0  .  .
.  .  .  .  .  .  .  .  .  .  .  .  .
.  .  .  .  .  .  .  .  .  .  .  .  .
.  0  .  .  0  .  .  0  .  .  0  .  .
```

If by chance a self-sterile variety has been planted in a solid block, the necessary pollinizer may be introduced by grafting. Some relief may be obtained during the years while waiting for the trees grafted over to pollinating varieties to come into bearing, by cutting off large limbs of pollinating varieties, placing the cut ends in buckets of water and distributing them throughout the orchard during the blooming period. Such limbs will live for several days and continue to bloom, forming pollen for the bees to transfer to the self-sterile variety.

SUMMARY OF PEAR POLLINATION

1. A 12 per cent cane sugar solution gave during the seasons of 1916, 1917, 1918, 1919, 1920, 1922, and 1923, an entirely satisfactory artificial germination of pear pollen.

2. There is comparatively little variation in the amount of pollen produced by various pear varieties. Pollen production is always abundant.

3. The blooming period of most pears is comparatively short.

4. With the exception of several of the earliest and latest bloomers all pear varieties overlap in their period of bloom.

5. Bartlett is to a limited extent self-sterile under interior valley and coastal conditions. Under Sierra Nevada foothill conditions it is almost entirely self-sterile (at least in certain years) and therefore should not be planted without pollinizers.

6. Winter Nelis has proved to be the best pollinizer for the Bartlett under all conditions tested.

7. Under valley conditions, the Comice, Bosc, and Hardy have proved to be satisfactory pollinizers for the Bartlett. Howell, Angouleme, Anjou, and Forelle have also given fair results.

8. Under coastal conditions, Comice, Clairgeau, and Easter proved satisfactory as pollinizers for the Bartlett.

9. Under Sierra Nevada foothill conditions, Bosc, Comice, Anjou, Easter, D. Hovey, and Howell are recommended as pollinizers for the Bartlett in the order named.

10. Winter Nelis has been largely self-sterile under all conditions tested but may be successfully pollinated with the Bartlett.

11. Alencon, Bloodgood, B. S. Fox, Comet, Forelle, LeConte, and Madeline have proved to be almost entirely self-sterile under valley conditions.

12. Comice, Flemish Beauty, Hardy, and Howell may be classed as self-fertile under valley conditions.

13. Angouleme, Anjou, Bosc, Clapp Favorite, Clairgeau, Col. Wilder, Dana Hovey, Easter, Gifford, Glout Morceau, Kieffer, P. Barry, and Seckel may be considered doubtful, and the writers would not recommend that they be planted under valley conditions without provisions for cross-pollination.

14. Under coastal conditions, Clairgeau, Comice, Howell, and Hardy are almost self-sterile.

15. Bosc, Easter, and Glout Morceau are fairly self-fertile under coastal conditions.

16. Anjou, Bosc, Comice, D. Hovey, and P. Barry should be considered self-sterile under foothill conditions.

17. Easter may perhaps be classed as self-fertile under foothill conditions; however, attention is here drawn to the fact that in the case of this variety only one season's results are available.

18. Pear fruits resulting from cross-pollination do not appear to exhibit the same tendency to fall after the June drop as do those resulting from self-pollination.

19. Pollinating agencies such as honey bees are necessary to set a good crop of fruit.

20. One stand of bees should be provided for each acre of orchard.

21. Care should be taken in the arrangement of varieties in the orchard to facilitate cross-pollination and convenience in orchard management.

ACKNOWLEDGMENTS

The writers wish to express their appreciation of the help they have received from the following persons in carrying out this work: Messrs. M. N. Wood, O. Lilleland, M. J. Heppner, R. Peckham; J. L. Stahl; Misses R. M. Amesbury and Edna Russ and to several advanced students in Pomology who rendered assistance in the field and laboratory. Dr. W. L. Howard has given service in suggestions and criticisms.

The Earl Fruit Company, Mr. A. L. Wisker of the Loma Rica Ranch, Mr. P. M. Beaser of Chicago Park, Mr. V. T. McCurdy, and Mr. F. Wilcox of Santa Clara Valley, and Mr. Don Searby of Sonoma County have kindly allowed the use of their orchards for certain experiments and have at all times shown a kindly and coöperative interest in the work.

8m–3,'24